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Method and apparatus for dynamic loading of a specimen

[Verfahren und Vorrichtung zur Erzeugung von stossartigen Belastungen an einem Prüfling]

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Method and apparatus for dynamic loading of a specimen

In the method for dynamic loading of a specimen, wherein a specimen is accelerated according to a preset function by means of a loading cylinder and is then decelerated to a standstill state, different acceleration forms should be developed such as half-sine, square, or saw-tooth in an extremely short test time of a few milliseconds. This is accomplished by the fact that the acceleration form is built up by controlling supply of fluid under pressure to a the first chamber (3) of a loading cylinder (1), by setting up a substantially constant but low counter-pressure in a second chamber (4) of the loading cylinder (1), acting in opposition to the accelerating force that is generated, and, after accelerating the piston (2) of the loading cylinder (1) and the specimen (8), bringing them to a standstill because of the counter-pressure in the second chamber (4) with a substantially constant deceleration. An apparatus for carrying out the method has a control spool valve (10) as well as a pressure accumulator (7) and/or a reducing valve (15) coupled to the second cylinder chamber (4).

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Method and apparatus for dynamic loading of a specimen

The invention relates to a method and apparatus for dynamic loading of a specimen, wherein the specimen is accelerated according to a preset function and is then decelerated to a standstill with the help of a hydraulic cylinder having a piston, two cylinder chambers, and an outwardly directed piston rod connectible to the specimen, as well as a valve for pressure fluid supply from a pressure fluid source to the loading cylinder.

[1] Numbers in the margin indicate pagination in the foreign text.

Methods and apparatuses for dynamic loading of specimens are used for building up stresses that occur, e.g., during accident events. In these methods, the acceleration should be provided, e.g., in the form of the half-sine, square, or saw-tooth type. The test time is in this case extremely short, and is, e.g., in the range of a few milliseconds. Accelerations range between 5 g and 1000 g. In such tests, it is required that the specimen be brought to a standstill with a preset deceleration that is as low and uniform as possible after a certain velocity has been reached.

In a known method, in which the specimen is accelerated in a desire manner by means of a hydraulic loading device, disengagement of the specimen from the acceleration device is provided after acceleration. The specimen is braked after testing, e.g., mechanically. This method is not suitable, e.g., in applications, where the tests should be conducted in a sequence. Also in a method in which a specimen is accelerated in a free fall to a certain velocity, the desired acceleration loading is affected during the braking of the specimen with the use of an absorber device.

It is an object of the present invention to provide a method for dynamic testing of a specimen, in which using simple means, various acceleration forms can be provided, with the subsequent deceleration being as constant as possible and not exceeding a preset level. An apparatus if provided as well for carrying out the method. This object is accomplished by using the limitations defined in the claims.

According to the invention, the problem of providing the preset value is simplified by controlling pressure fluid supply to the loading cylinder. Undesired loading peaks during deceleration of the specimen are eliminating by using a constant counter-pressure in the deceleration phase. Further, the method according to the invention allows for working in a sequence.

In an embodiment of the method, both cylinder chambers of the loading cylinder are advantageously connected to each other

during deceleration of the specimen, with the counter-pressure being produced by means of a pressure accumulator and/or a pressure reducing valve.

An apparatus for carrying out the method preferably has a valve that is made as a control spool valve, which connects a pressure fluid source to the first cylinder chamber or to both cylinder chambers, and the second cylinder chamber is connected to the pressure accumulator and/or to the pressure reducing valve. Other preferred embodiments of the invention are defined in sub-claims.

The invention will now be described with reference to a practical embodiment. The accompanying drawing schematically shows a hydraulic loading apparatus for dynamic testing, having a loading cylinder, a servo valve, a pressure accumulator, and a pressure reducing valve.

The hydraulic loading apparatus consists of a loading cylinder 1 having a piston 2, a first cylinder chamber 3, and a second cylinder chamber 4, as well as an outwardly extending piston rod 5. A specimen 6 is mounted on the piston rod. The piston rod 5 can extend from the loading cylinder on one side, or it can extend outside on both end sides of the cylinder as shown in the drawing.

A pressure accumulator 7, which can be made, e.g., as hydraulic accumulator, is connected to the cylinder chamber 4. The accumulator can be filled with fluid through a line 8 and an orifice or control device 9 and can be adjusted to a preset pressure. It can receive and deliver pressure fluid at an approximately constant pressure.

A servo valve 10 is provided for controlling pressure fluid supply to the loading cylinder 1. The valve functions in a known manner, having a spool 10a and control edges 10b of the spool and of the spool casing, with only one side of the valve being

necessary in this case. The servo valve has a pressure fluid supply connector 11, which is connected to a pressure fluid

source and which is capable of delivering the required pressure fluid at a preset system pressure. Two more pressure fluid connectors 12 and 13 are used to connect the servo valve to the loading cylinder 1. The intermediate pressure connector 12 is connected, via a line 12a, to the first cylinder chamber 3 of the loading cylinder, and the connector 13 is connected, via a line 13a, to the second cylinder chamber 4 and to the pressure accumulator 7.

The servo valve 10 can be shifted in such a manner as to either put the first cylinder chamber 3 under the system pressure via the line 12 (as shown in the drawing) with the pressure fluid supply being controlled, or to connect both cylinder chambers, 3, 4 to each other through the lines 12a, 13 (when the spool 10a is shifted to the left). The first shift position is used for acceleration, and the second shift position is used for deceleration of the specimen 6. A spool valve control is not shown.

A pressure reducing valve 15 is also connected to the loading cylinder 1, which is used to set up the maximum pressure level in the cylinder chamber 4. This allows for preventing undesired overpressure from building up in this cylinder chamber.

The above-described loading device functions in the following manner. Before starting the dynamic test, the piston 2 in the loading cylinder 1 is in its initial position, on the left end of the cylinder in this specific example. The servo valve 10 is opened, and pressure fluid, which can be at the maximum possible system pressure of, e.g., 280 bar, is admitted to the first cylinder chamber 3 through the line 12. During the pressure fluid admission, the servo valve is controlled in such a manner as to produce a desired form of acceleration with a corresponding acceleration occurring on the piston, piston rod, and specimen. The servo valve is modulated, more specifically, it is subjected to the required valve opening and control according to the theoretical estimates and/or test program. The

acceleration time is very short, and it is within a few milliseconds range. The accelerations that are produced can be as high as 1000 g and even higher.

After the acceleration phase, the servo valve 10 is switched over, and it is shifted in such a manner that the first and second cylinder chambers 3, 4 are connected to each other through the lines 12a and 13. During the entire test cycle, a substantially constant and relatively lower pressure is maintained in the cylinder chamber 4 and in the pressure accumulator connected to this chamber. For instance, the pressure in the pressure accumulator can amount to about 10% of the system pressure, more specifically, with the system pressure of 280 bar, it will be about 25 bar. This pressure is not established instantly after the end of the acceleration phase This pressure does not appear after the end of the acceleration phase because of the instant high velocity of the piston 2 to achieve the rapid equalization of pressure in both chambers of the loading cylinder. For this reason, the cylinder chamber 3 still remains connected to the cylinder chamber 4 initially substantially without any pressure. The piston 2 can, therefore, be braked by the almost constant counter-pressure established in the cylinder chamber 4.

The servo valve 10 is controlled in the deceleration phase in such a manner that pressure equalization in both cylinder chambers occurs when the piston 2 is braked to a standstill. Modulation of the servo valve 10 and valve opening is set up based on a theoretical estimate and/or practical tests. The pressurized fluid is pumped over from the cylinder chamber 4 into the cylinder chamber 3 during the deceleration phase because of the controlled short-circuit. Surplus pressurized fluid can be taken up by the pressure accumulator 7 of fed through the pressure reducing valve 15.

If the pressure reducing valve 15 is designed in such a manner as to have a rapid response and ensures the required pressure stability in the cylinder chamber 4, the pressure

accumulator 7 can be dispensed with. The kinetic energy generated during the tests is not taken up by the pressure accumulator, and it is rather damped in the pressure reducing valve.

In the dynamic test described herein, the piston stroke in the acceleration phase amounts only to a small part of the stroke in the deceleration phase.

In lieu of the servo valve, a proportional valve or a similarly functioning spool valve that can perform the above-described switching and control functions could be used in the method and apparatus according to the invention.

To return the piston 2 to the initial position for a dynamic test (from the right hand end position to the left hand end position in the drawing), the piston surface area, e.g., in the first cylinder chamber 3 can be made somewhat smaller than that in the second cylinder chamber 4. Because of this, the piston will automatically move back to the initial position when the pressure in both cylinder chambers becomes the same. With the upright position of the loading cylinder, the piston will move automatically under gravity to its initial position if the

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apparatus is designed in such a manner that the first cylinder chamber 3 is in the bottom and the second cylinder chamber 4 is at the top. Other methods, e.g., mechanical means can be used to return the piston to the initial position.

Claims

1. A method for dynamic loading of a specimen, wherein the specimen is accelerated according to a preset function and is then decelerated to a standstill with the help of a hydraulic loading apparatus having a hydraulic loading cylinder, a piston, two cylinder chambers, and a piston rod extending outwardly and connectible to the specimen, as well as a valve for supplying pressurized fluid from a pressurized fluid source to the

loading, characterized by the fact that the form of acceleration is produced by controlling pressurized fluid supply to the first chamber (3) of the loading cylinder (1), that a substantially constant yet lower counter-pressure acting in opposition to the acceleration force that is generated is established in the second chamber (4) of the loading cylinder, and by the fact that piston (2) and the specimen (6) are braked to a standstill after the acceleration by the counter-pressure in the second cylinder chamber (4) with a substantially constant deceleration.

2. The method of claim 1, characterized by the fact that both cylinder chambers (3, 4) of the loading cylinder (1) are connected to each other through a valve (10) during deceleration of the specimen (6).

3. The method of claim 1 or 2, characterized by the fact that the counter-pressure is generated by a pressure accumulator (7) or by a pressure reducing valve (15).

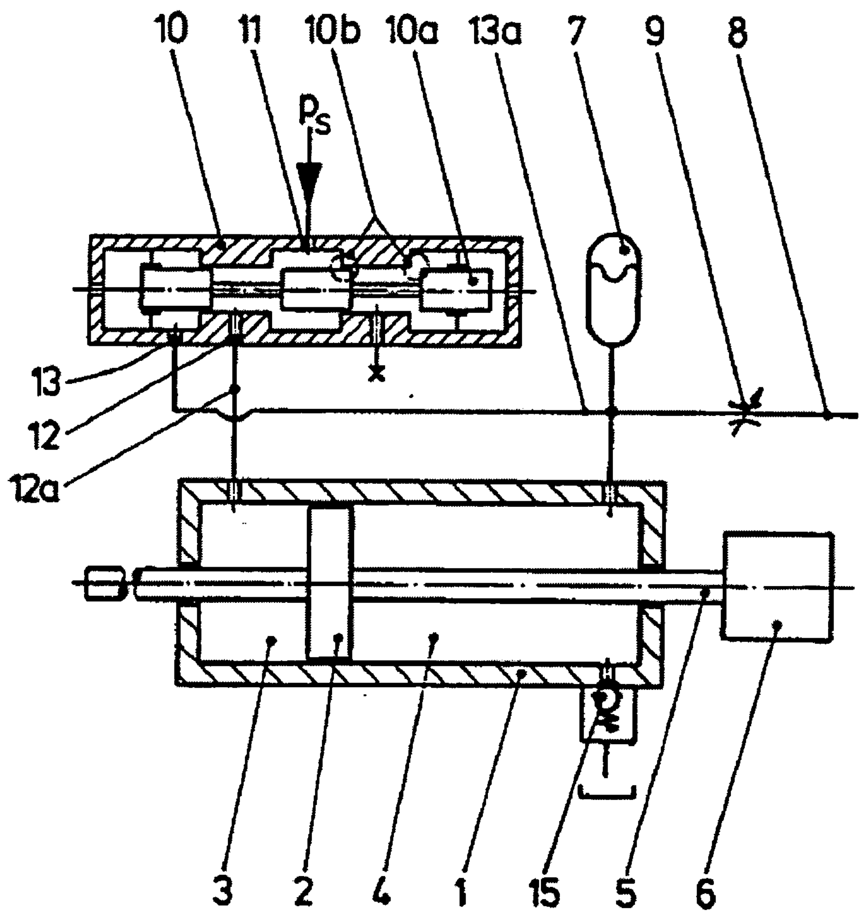
4. An apparatus for dynamic testing of a specimen, having a hydraulic loading device, which consists of a hydraulic loading cylinder having a piston, two cylinder chambers, and an outwardly extending piston rod connectible to the specimen, as well as a valve for supplying pressurized fluid from a pressurized fluid source to the loading cylinder for carrying out the method of claim 1, characterized by the fact that the valve (10) is made as control spool valve, that the pressurized fluid source is connected to the first cylinder chamber (3) or both cylinder chambers (3, 4) are connected to each other, and that the second cylinder chamber (4) is connected to a pressure accumulator (7) and/or a pressure reducing valve (15).

5. The apparatus of claim 4, characterized by the fact that the control spool valve is made as a servo valve (10) or as a proportional valve.

6. The apparatus of claim 4 or 5, characterize by the fact that a device for bringing the piston back to its initial position is provided in the loading cylinder (1).

7. The apparatus of claim 4 or 5, characterize by the fact that the piston surface area in the first cylinder chamber (3) is made slightly smaller than the piston surface area in the second cylinder chamber (4).

8. The apparatus for any of claims 4 through 7, characterized by the fact that the pressure in the pressure accumulator (7) can be adjusted.



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METHOD OF TESTING HYDRAULIC UNITS

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